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THE EFFECT OF TALC-CHLORITE SCHIST ON PROPERTIES OF CERAMIC TILES

V. P. Il'ina,¹ G. A. Lebedeva,¹ G. P. Ozerova,¹ and I. S. Inina¹

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In order to use fine-fraction talc-chlorite to improve the properties of ceramics, they were tested as a grog additive to clay in ceramic tile mixtures. The use of talc-chlorite increases the strength and decreases the shrinkage of tiles, compared to traditional mixtures, and ensures a minimum number of components in the batch.

Two deposits and more than ten manifestations of talc-chlorite rocks are known on the territory of Karelia. The current application of talc-chlorite is mainly related to the production of large-block stones for making fireplaces and household items. In extracting these blocks, part of the rocks breaks into smaller pieces. Furthermore, some rocks are highly schistose and unsuitable for producing blocks.

For the purpose of using fine-fraction talcum-chlorite to improve properties of ceramics, they were tested as a grog component in clay mixtures for ceramic tiles.

The positive effect of talc on the properties of ceramic mixtures had been established earlier. Thus, adding concentrated talc, talc schist, and talc quarry waste to tile mixtures together with quartz sand and various industrial waste (red slime, alumina production waste, broken tiles, glass cullet) increases mechanical strength, heat resistance, and firing interval, and decreases shrinkage (USSR Inventor's Certif. Nos. 457680, 924010, and 1211241), and adding talc-chlorite schist into brick mixtures significantly improves their frost resistance and decreases the shrinkage of brick [1].

Considering the variability of talc-chlorite schist composition, we investigated two samples that were taken from the

overburden rocks of the Kostomukshskoe deposit (sample 1) and from the Turgan-Koivan-Allusta deposit (sample 2). The chemical compositions of the samples are listed in Table 1.

The mineral composition of materials was identified using optical microscopy, x-ray phase analysis, differential thermal analysis (DTA), and thermogravimetric analysis (DTG).

According to DTA data, within the temperature interval up to 1000°C one observes the dehydration (endothermic effects at 605 and 680°C — sample 1; at 610°C — sample 2) and recrystallization of chlorites (exothermic effects at 840°C — sample 1 and at 870°C — sample 2), decomposition of dolomites (endothermic effects at 815–830°C — sample 1; at 800–840°C — sample 2), dehydration of talc (endothermic effects at 980°C — sample 1 and at 950°C — sample 2).

The content of talc in the material is calculated based on the quantity of H₂O released in the dehydration of talc, which is determined by DTG analysis. The schist samples differ in their mineralogical and, accordingly, their chemical compositions (Table 1). Sample 1 consists of talc (54%), chlorite, and amphibole with a dolomite impurity (2%). The main minerals in sample 2 are talc (32%), chlorite, and dolomite with a small quantity of magnetite (5%). The main dis-

¹ Institute of Geology of the Karelian Scientific Center of the Russian Academy of Sciences, Russia.

TABLE 1

Material	Mass content, %										
	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃	FeO	MnO	MgO	CaO	Na ₂ O	H ₂ O	calcination loss
Sample:											
1	54.00	0.24	4.32	0.45	6.25	0.04	28.42	0.36	0.02	0.05	6.16
2	36.40	0.22	4.59	6.82	3.76	0.20	26.57	5.63	0.02	0.02	15.41
Clay*	62.70	0.85	15.45	3.24	2.70	0.03	2.50	0.97	0.21	1.11	4.46

* In addition, the clay contains 5.19% K₂O.

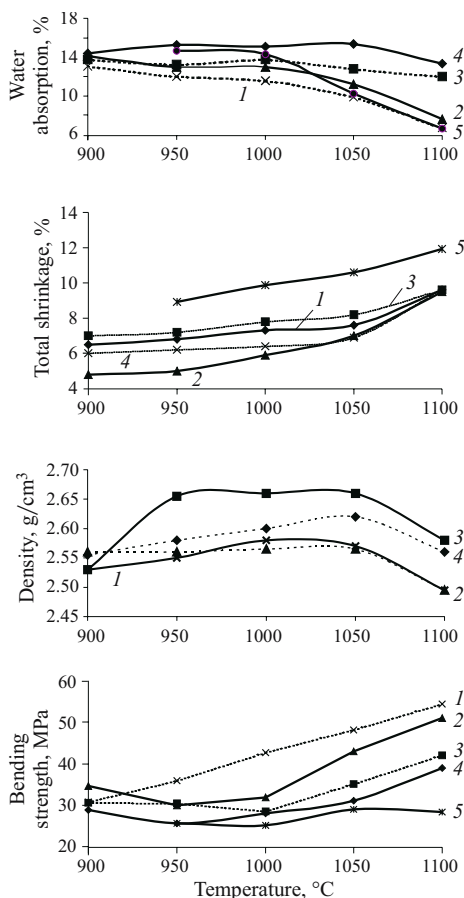


Fig. 1. Dependence of tile properties on firing temperature. Content of talc-chlorite: 1) 30%; 2) 40% (sample 1); 3) 30%, 4) 40% (sample 2); 5) industrial mixture.

tinction of talc-chlorite in samples 1 from sample 2 is its lower content of carbonate minerals and a higher content of silicates.

The argillaceous component was clay from the Chekalovskoe deposit consisting of quartz, hydromica, chlorite, and feldspar. This clay is used at the Nikolskii Works (Leningrad Region) for producing ceramic tiles.

Experimental mixtures were investigated according to the standard technology. Batch preparation included drying, grinding, screening, weighing, and mixing batch components in a laboratory ball mill to a residue of 1.5% on a No. 0063 sieve. After 24-h aging, the working moisture of the mixtures was 18–20%. To determine their sinterability and strength, tiles of size 50 × 50 × 8 mm were molded.

Tiles were subjected to preliminary drying at a temperature of 900–1100°C with a step of 50°C. The rate of temperature rise was 2–3 K/min, the exposure of samples in a furnace upon reaching a required temperature was 40 min. Samples were cooled together with the furnace.

The physicomaterial properties of tiles were determined according to GOST 6141–91.

TABLE 2

Structural characteristics of vitreous phase*	Mixture 1	Mixture 2
Integral intensity, pulses · deg/sec	136.70 ± 0.72	77.71 ± 0.51
Doublet gravity center, deg	26.02 ± 0.11	23.54 ± 0.09
Interplanar distance, Å	3.423 ± 0.014	3.770 ± 0.010
Profile maximum minus background, pulses/sec, at 2Θ:		
25.85°	10 ± 1	—
23.20°	—	8 ± 1
Integral width of doublet, deg	13.19 ± 1.01	9.80 ± 0.82

* Firing temperature 1100°C.

We investigated the properties of two-component tile mixtures containing 20–60% talc-chlorite and clay. Phase transformations in ceramic mixtures within a temperature interval of 950–1100°C were studied on samples containing 40% talc chlorite of sample 1 (mixture 1) or sample 2 (mixture 2).

It was found by x-ray phase analysis that recrystallization of talc with the formation of clinoenstatite starts in ceramic mixtures at a temperature of 950°C, then at 1000°C the intensity of talc lines sharply decreases, whereas the intensity of clinoenstatite lines increases. At a temperature of 1000–1050°C hydromica contained in the argillaceous material disintegrates. A certain increase in the halo integral intensity on the diffraction patterns points to the trend toward a growing vitreous phase as the tiles were fired within a temperature interval of 950 to 1100°C. This is also corroborated by data on the dependence of density on firing temperature (Fig. 1). The phase composition of tiles at 1050–1100°C is mainly represented by quartz, clinoenstatite, and the vitreous phase. Figure 2 shows the diffraction patterns of the vitreous components (halo) of ceramic mixtures 1 and 2; their structural characteristics were calculated (Table 2), indicating the different chemical compositions of their vitreous phases. The increased integral halo intensity in mixture 1 compared to mixture 2 is presumably caused by their different chemical compositions and by the increased quantity of the vitreous phase. This is a consequence of the higher acidity of talc-chlorite in sample 1, which has a higher content of silicate minerals.

The effect of firing temperature on the properties of ceramic mixtures is investigated on compositions containing 30–40% talc-chlorite (Fig. 1). It is established that the total shrinkage grows at a temperature of 1100°C, which points to a better sinterability of mixtures. This decreases water absorption and increases mechanical strength. Thus, the optimal temperature for firing tiles is 1100°C.

Increasing the content of talc-chlorite (both samples) from 20 to 40% at the optimum temperature raises mechanical strength and decreases the shrinkage of tiles. Upon a further increase in talc-chlorite content to 60%, one can observe a decrease in strength and a significant increase in water ab-

sorption, as a result of poor sinterability due to the increased share of the grog component. Therefore, the optimum quantity of talc-chlorite in a ceramic mixture should be equal to 30–40%.

In using optimum composition, fired tiles with talc-chlorite of sample 1 have higher strength and lower water absorption than tiles containing talc-chlorite of sample 2. This is presumably a consequence of the better sinterability due to the higher amount of the vitreous phase. There is no difference in the total shrinkage of tiles using samples 1 and 2 (Fig. 1).

Let us also compare the properties of fired tiles with talc-chlorite and tiles made of mixtures produced at the Nikolskii Works (Fig. 1), which consisted of clay from the Chekalovskoe deposit, quartz sand, kaolin, and lime.

The tiles with tack-chlorite have higher strength (twice as high for sample 1 and 40% higher for sample 2) and a shrinkage lower by 25% for both samples. The water absorption of industrially produced tiles and tiles with talc-chlorite of sample 1 are virtually identical, whereas the water absorption of tiles with talc-chlorite of sample 2 is higher but still within the limits prescribed by the requirements of GOST 6141–91 standard (up to 16%).

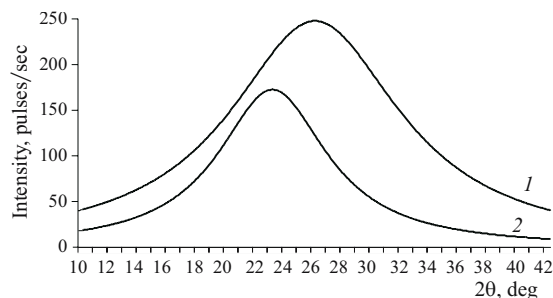


Fig. 2. Diffraction patterns of the vitreous phase in ceramics (firing temperature 1100°C). Curve numbers correspond to mixture numbers.

Thus the application of talc-chlorite as a grog additive in a ceramic mixture increases the tile strength and decreases shrinkage compared to the traditional mixture. Furthermore, in this case the mixture has a minimum number of components.

REFERENCES

1. V. I. Sokolov, *Talc-Chlorite Schist from Karelia and Methods for Its Integrated Application* [in Russian], Petrozavodsk (1995).